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10/534653

JC05 Rec'd PCT/PTO 12 MAY 2005

Device for examining filled containers by means of
X-rays and use of this device

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Description

10 The invention relates to a device for examining filled containers for foreign bodies, such as glass splinters, with a transport apparatus for transporting the containers individually in succession in a row on a plane of transport, with an X-ray source for emitting an X-ray in a predetermined direction and with an apparatus for recording the X-rays after they have passed through the containers.

15 The checking of goods which are packed in containers, for example fruit juices in drinks bottles, by means of X-rays is a process known in the food industry. Problems arise when checking for foreign bodies which have a higher density than the packed goods and therefore fall to the bottom of the containers. In the case of containers with a dished bottom, as is the case with many drinks bottles, the foreign bodies slide on the bulge of the container bottom to the inner container edge.
20 There, they are hard to recognize by means of X-rays, as the X-rays must penetrate not only the vertical container wall but also the bottom of the container, during which process they are oriented, because of the bulge of the container bottom, at an angle of for example 10° to the dished surface of the container bottom and therefore travel a very long distance inside the container material. An
25 additional attenuation of the X-rays by any foreign bodies present therefore has only relatively little effect and is frequently no longer detectable. On the other hand, unevennesses in the surface of the container bottom can easily be taken for a foreign body.

30 It is known from EP-A-0 795 746, to solve this problem, to examine the containers using two X-rays, one of which points 45° in the direction of transport and the other 45° against the direction of transport, with the result that they are at right angles to each other.

It is known from EP-A-0 961 114 to turn the containers upside down for this examination, with the result that any foreign bodies present drop down to the closure and can be recognized with certainty by means of X-rays as they do so.

- 5 It is known from WO 01/44791 to tilt the containers sideways by roughly 80° and then examine them for foreign bodies using a vertically directed X-ray.

The object of the invention is to improve the reliability of the recognition of foreign bodies in filled containers.

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According to the invention this object is achieved in the case of a device of the type mentioned at the outset in that the direction in which the X-rays are emitted from the X-ray source is inclined by between 10° and 60°, preferably 15° and 45°, and in particular approximately 30° to the plane of transport.

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A suitable X-ray source produces for example an X-ray with 50 to 100 keV, in particular with 60 keV.

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Dished container bottoms generally have a maximum slope of between approximately 10° and 60° at the edge. The X-ray source is positioned such that, at the point of the maximum slope of the container bottom – which is generally at the edge of the container bottom - the course of the ray is roughly tangential to the bulge of the container bottom. This can be achieved by having an X-ray source arranged both above the plane of transport and below the plane of transport.

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If the X-ray source is arranged above the plane of transport, the upper part of the X-ray travels, in the area facing away from the X-ray source of the container bottom, approximately tangentially to the bulge of the container bottom. As a result, the X-ray penetrates the material of the container only on the front and on
30 the back of the wall, but does not travel an extended distance inside the container bottom. If the inclination is for example 30°, the section inside the vertical container wall increases by only approximately 15%. Consequently, the contrast of intensity

differences that is caused by foreign bodies is reduced only to an insignificant extent.

Similarly favourable conditions apply in the area of the inner edge facing the X-ray source of the container bottom. Here the container bottom rises at an angle of for example 30° , and so the X-ray then travels at an angle of 60° to the container bottom, with the result that here too the distance travelled is extended by only approximately 15% compared with an incidence at a right angle.

The X-ray can also be directed from below at an angle of for example 30° to the plane of transport towards the container bottom. In the area facing the X-ray source, the X-ray then travels approximately tangentially to the bulge of the container bottom, whereas in the area edge facing away from the X-ray source of the inner edge of the container bottom it then travels, in the chosen case, at an angle of approximately 60° to the container bottom.

In every case the X-rays are preferably aligned roughly at a right angle to the direction of transport.

In a particularly preferred version of the invention, the containers are examined using two X-rays, one of which is directed from above, and the other from below, towards the container bottom. Both X-ray sources are preferably arranged on the same side of the transport apparatus. The angles at which the X-rays are directed towards the container bottom can be the same or different. They are preferably approximately 30° . It is also possible to use still further X-ray sources, for example a third X-ray source which directs an X-ray parallel to the plane of transport or at a different angle from the first and second X-ray sources onto the container bottom. The angle of the X-rays to the direction of transport can also be different.

The apparatus for recording the X-rays is arranged on the side lying opposite in relation to the direction of transport of the X-ray source. This apparatus can be a line or a two-dimensional field of X-ray detectors. The X-ray detectors can be photodiodes with a scintillation crystal. However, the recording apparatus is

preferably an X-ray image converter or X-ray image intensifier with downstream CCD camera. Through the use of such an area sensor, the necessary exposure time is minimized and the exposure of the product and the environment to the ray thus reduced.

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An apparatus for recording the X-rays and for evaluating the items of information is allocated to each X-ray source. By comparing the information supplied by the individual recording apparatuses, a three-dimensional position determination of the defects is possible, as a result of which foreign bodies can be distinguished from defects in the material of the container wall.

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When using two X-rays, the images are preferably coupled on an area sensor. The divergence angle of the X-rays and the distance between the X-ray sources and the transport apparatus on one side and the distance between the area sensor and the transport apparatus on the other side are matched to each other such that the image produced by the X-ray coming from below appears in the upper half of the area sensor, while the image produced by the X-ray coming from above appears in the lower half of the area sensor. Defects which emerge in one image can be sought and confirmed in the other image.

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The transport apparatus can be a customary link-chain conveyor with plastic chain links. If the chain links interfere on the X-ray image, a belt conveyor can be used in which the containers are transported by means of two laterally engaging belts. Such a transport apparatus is known from EP-A-0 124 164. The bottom of the containers is not supported. The plane of transport is defined by the container bottoms. It preferably lies horizontal. In particular when using a belt conveyor, it can however also be inclined.

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The subject-matter of the invention is also the use of the previously described device for examining filled containers for foreign bodies, in particular glass bottles with a dished bottom. The X-ray source or the X-ray sources are preferably positioned such that, at the point of the maximum slope of the container bottom, the course of the ray is roughly tangential to the bulge of the container bottom.

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Embodiments of the invention are explained below with the help of the drawing.
There is shown in:

5 Fig. 1 an embodiment in which the X-ray is directed from above at an angle of 30° towards the plane of transport;

Fig. 2 an embodiment in which the X-ray is directed from below at an angle of 30° towards the plane of transport;

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Fig. 3 an embodiment with two X-rays viewed in the direction of transport and

Fig. 4 the embodiment of Fig. 3 in side view.

15 In the embodiments the containers are in each case glass drinks bottles 10 which, in the lower area, have a cylindrical wall 12 and a dished bottle bottom 14. The bottles 10 are transported standing upright on a transport apparatus 16. The transport apparatus 16 is a customary link-chain conveyor. A 60 keV X-ray source 18 is arranged at a distance next to the transport apparatus 16 on one side, and on
20 the other an apparatus for recording the X-rays. This apparatus is an area sensor in the form of an X-ray image converter 20. The image produced by the X-ray image converter 20 is recorded by a CCD camera 22.

The top of the transport apparatus 16 defines a plane of transport. In the
25 embodiment of Fig. 1 the X-ray 24 is inclined by an angle of 30° from above towards the plane of transport. The distance between the X-ray source 18 and the transport apparatus 16 is approximately 30 cm and the X-ray 24 has a divergence of 15° , with the result that the whole bottle bottom, which has a diameter of approximately 7 cm, lies within the X-ray 24. The X-ray image converter 20 is
30 arranged at the smallest possible distance next to the transport apparatus 16 and covers at least the area of the X-ray 24 which has penetrated the bottle bottom 14.

In the represented embodiment of Fig. 1, there is a foreign body 26, for example a glass splinter, on the side facing away from the X-ray source 18 of the inner edge of the bottle bottom 14. The foreign body 26 absorbs or scatters the X-rays and can be recognized on the X-ray image converter 20 as a dark spot 32. As can be seen in Fig. 1, the rays in the immediate vicinity of the rays which strike the foreign body 26 penetrate the front and back of the wall 12 of the bottle 10 at an angle of approximately 60° . This also applies to the rays travelling immediately thereunder, which travel approximately tangentially to the bulge of the edge of the bottle bottom 14. On the other hand, the rays lying even somewhat deeper travel a relatively long distance inside the bottle bottom 14 and are thereby very markedly attenuated, unevennesses in the top or bottom of the bottle bottom 14 having a particularly marked effect. The rays in the immediate surroundings of the foreign body 26 are very uniformly attenuated, however, with the result that the foreign body 26 can be recognized through a clear brightness contrast on the X-ray image converter 20.

In the embodiment of Fig. 2 the X-ray source is arranged below the plane of transport and the X-ray 24 is directed at an angle of 30° from below towards the plane of transport. The same foreign body 26 as in Fig. 1 also stands out clearly against its surroundings in this case. The resulting angle at which the rays in the area surrounding the ray striking the foreign body 26 are directed towards the bottle bottom 14 is $30^\circ +$ the slope of the edge of the bottle bottom 14, which is typically also 30° . Any unevennesses in the material thickness in the bottle 10 thus have only a slight effect. As regards the arrangement of the X-ray image converter 20 and the CCD camera 22, the embodiment of Fig. 2 corresponds to that of Fig. 1.

In the embodiment of Figs. 3 and 4, two X-ray sources 18 are provided, the X-ray 24 emitted from the first X-ray source 18 being directed at an angle of 30° from above towards the plane of transport, while the second X-ray source 18 is arranged below the plane of transport and the X-ray 24 emitted from it is directed at an angle of 30° from below towards the plane of transport. The distance between the X-ray sources 18 and the transport apparatus and the divergence of the emitted X-rays 24 and also the size of the X-ray image converter 20 and its distance from the transport apparatus 16 are chosen such that the image produced by the first X-ray

24 is located in the lower half of the X-ray image converter 20 and the image 30 produced by the second X-ray 24 in the upper half of the X-ray image converter 20. The foreign body 26 is again arranged as in Figs. 1 and 2 and it produces a spot 32 of reduced brightness both in the first image 28 and in the second image 30. Both
 5 images are taken using a single CCD camera 22. The precise spatial position of the foreign body 26 can be established, using customary image-processing methods, from the position of the two spots 32. If this position lies on the outside of the wall 12 of the bottle 10, it can be concluded from this that it is not a foreign body 26 inside the bottle 10, but for example a raised point on the outside of the wall 12.
 10 The bottle 10 is then not defective.

The conditions as regards the course of the X-rays 24 to the bulge of the bottle bottom 14 and to the container walls 12 are transposed in the embodiments of Figs. 1 and 2 if the foreign body 16 is located, not on the side facing away from the X-ray
 15 sources 18 of the bottle bottom 14, but on the side facing them of the bottle bottom 14.

As regards the accuracy of recognition and the sharpness of contrast of the spot 32 of reduced intensity caused by the foreign body 26 on the X-ray image converter 20, the same conditions obtain for the first image 28 as in the embodiment of Fig. 1, and the same conditions as in the embodiment of Fig. 2 in the case of the second image 30. The conditions are again transposed if the foreign body 26 is located on
 20 the side facing the X-ray sources 18 of the bottle bottom 14.

List of reference numbers

10	Bottle
12	Wall
14	Bottle bottom
16	Transport apparatus
18	X-ray source
20	X-ray image converter
22	CCD camera
24	X-ray
26	Foreign body
28	First image
30	Second image
32	Spot